

**REMARKS**

Claims 1-29 are pending in the present application. Applicants respectfully submit that the presently claimed invention patentably distinguishes over the prior art in general and over the asserted combination of Nakayama et al. and Tanimoto et al. in particular. Accordingly, Applicants respectfully request reconsideration and withdrawal of the rejections of Applicants' claims over the asserted combination of references, for at least the reasons set forth in the following.

Claims 1-4, 12, 13 and 16 are amended herein to clarify that the claimed printed circuit boards comprise immersion plated metals, both the tin layer and the alloy cap layer. Claims 22-29 already recite immersion plating of the metals in both the tin and alloy cap layers. The Examiner noted this with respect to the alloy cap layer at page 7 of the final Office Action. Applicants respectfully submit that these amendments are fully supported in the specification and claims as originally filed, and thus contains no new matter.

Applicants respectfully request entry of the presently submitted after-final Reply, on the grounds that (1) the proposed amendments render allowable all of the pending claims, for the reasons set forth herein below, (2) the amendments include subject matter which has already been considered, and so do not require any additional search or consideration, and (3) the amended claims will be in better form for Applicants' appeal, should the Examiner not agree that the claims are allowable over the prior art of record.

Applicants submit herewith an amended drawing in response to the Examiner's request therefor. The drawing has been amended to include cross-hatching on all of the layers since, as disclosed in the specification, all of the layers comprise metal. Applicants request the Examiner to enter the drawing and to indicate approval thereof.

**Claim Rejections**

In the Office Action, claims 1-29 remain rejected as obvious over Nakayama et al., U.S. Patent No. 4,935,312, hereafter Nakayama et al., in view of Tanimoto et al., U.S. Patent No. 6,110,608, hereafter Tanimoto et al. Applicants respectfully traverse these

rejections for at least the following reasons, in addition to the reasons set forth in Applicants' first Reply to Office Action, which are incorporated herein by reference and apply to the claims as presently amended to the same effect as to the original claims.

Nakayama et al. discloses film carriers for mounting electronic components such as semiconductor chips thereon which have lead portions, such as copper, plated with a tin or tin alloy layer, which tin or tin alloy layer is covered by an electroless plated indium outer layer. Abstract. Nakayama et al. fails to disclose or suggest any metal other than indium for the outer layer. As discussed below, Nakayama et al. teaches away from tin alloys.

Tanimoto et al. discloses a lead material on which is formed a double-layer structure: a first electroplated layer; and a second electroplated layer. Col. 4, lines 5-8. Tanimoto et al. teach the melting temperature of the uppermost layer, that is, the second electroplated layer, is lower than the melting temperature of the lowermost, first electroplated layer. Col. 4, lines 8-14. Either of Tanimoto et al.'s layers may be tin or tin alloy; the critical distinction is that the uppermost layer should have a melting point lower than the lowermost layer. See, e.g., claim 1 of Tanimoto et al. Tanimoto et al. teaches only electroplating or hot dipping. Tanimoto et al. fails to teach or suggest immersion plating of any metal.

The Examiner's asserted combination of Nakayama et al. and Tanimoto et al. cannot render obvious Applicants' claimed invention, since the combination fails to disclose all the features of Applicants' claimed invention, there is no motivation to make the asserted selection and combination of particular elements from the cited references, and there can be no expectation of success in the asserted combination.

### **1. The Immersion Plated Tin and Alloy Cap Layers Distinguish Over the Prior Art.**

Applicants herein have amended claims 1-21 to recite that in both the tin and alloy cap layers of the metals are immersion-plated. Claims 22-29 previously recited that in both the tin and the alloy cap layer the metals are applied by an immersion plating process, thus both the tin and the alloy cap layers of these claims comprise immersion-plated metals.

Applicants respectfully submit that this feature distinguishes the presently claimed invention over the asserted combination of prior art references, for at least the following reasons.

In the rejections, the Examiner asserted with respect to claims 22-29 that “the process limitation defines the claimed invention over the prior art to the degree that it defines the product itself”, and asserted that it cannot so distinguish when the product is the same as, or is obvious over, the prior art. The Examiner cited *In re Thorpe*, 227 USPQ 964 (Fed. Cir. 1985) in support of this assertion with respect to the presently claimed invention.

However, *In re Thorpe* is inapposite to the present situation, since in that case the applicant did not dispute that the same product was obtained. *In re Thorpe* stands for the proposition that once the examiner shows a prima facie case that the product of the process is the same product as in the prior art, the burden shifts to the applicant to submit evidence of a difference. In the present case, Applicants submit that the products are different and that the difference would not have been obvious. Applicants submit herewith factual evidence in support of the difference, which evidence Applicants respectfully submit rebuts the position of the Examiner that the product is the same as or obvious over the prior art product.

As previously noted, in making the rejection of Applicants' claims, the Examiner admitted that the primary reference, Nakayama et al., fails to disclose an alloy cap layer, but asserted that it would have been obvious to use the alloy layer of Tanimoto et al. in place of the indium outer layer of Nakayama et al. Applicants have previously pointed out the lack of motivation to make the asserted combination (including a teaching away from an alloy layer in the primary reference), the lack of a reasonable expectation of success, and the absence of all of the claimed elements in the prior art references cited and relied upon. Each of these missing elements, either separately or together, destroys any possible *prima facie* case of obviousness. Applicants reiterate those arguments here, and

incorporate by reference each of them, and respectfully submits that there is no *prima facie* obviousness.

However, even if the Examiner has stated a *prima facie* case of obviousness based on the argument that the products are the same or would have been obvious, Applicants respectfully submit that the evidence rebuts this position.

Tanimoto et al. teaches only electroplating or hot dipping an alloy layer (col.6, line 35), and fails to teach or suggest that the alloy layer be formed by an immersion plating process. The Examiner has posited that an immersion plated layer would be the same as, or would have been obvious over, the electroplated alloy layer of Tanimoto et al.. Applicants disagree with this position, and respectfully submit that this position is clearly erroneous, for at least the following reasons. As would be known to any person of ordinary skill in the art, and as shown by the following, an alloy layer formed by electroplating or hot dipping would be quite different from an alloy layer formed by immersion plating. The immersion plating process is quite different from an electroplating or hot dipping process, and it would not have been obvious to shift from electroplating or hot dipping to immersion plating.

Applicants submit herewith documentary evidence showing that an immersion-plated metal layer is different from an electroplated metal layer. Applicants submit that, based on this difference, use of immersion plating results in the formation of a different material. When this difference is taken together with the teaching away from immersion plating an alloy layer in Nakayama et al. (noted by Applicants in the previous Reply to Office Action), Applicants submit that the presently claimed invention would not have been obvious based on the asserted combination of these references.

First, Applicants submit U.S. Patent No. 4,234,621, which provides a detailed discussion of the many differences between an immersion plated metal layer and an electroplated (or electrodeposited) metal layer. As noted in the '621 patent, at col. 2, lines 51-58:

An advantage of the immersion processes over many of the other aforementioned processes is the absence of hydrogen generation (or other gases) on the plating surface, thereby avoiding pitting or similar plating discontinuities. Also the immersion plating process is not subject to the surface roughness found in electroplating due to "drag-over" from precleaners, anode corrosion, and the like.

As shown, the structure of an immersion plated layer differs in that it is free of pitting or similar plating discontinuities. Such pitting or discontinuities could give rise to, or facilitate the formation of, tin whiskers when an electroplated metal layer is formed over a tin layer. In addition, the immersion plated layer is free of surface roughness, which could also give rise to, or facilitate formation of, tin whiskers due to the uneven thickness of the electroplated layer.

The '621 patent further discloses, at col. 3, lines 5-19:

Tin and some solders are subject under certain conditions to growth from their surfaces of metallic filaments known as "whiskers." These dendritic formations can in time and under proper conditions project from the surface to a length (as much as 1/4 of an inch) sufficient to short out adjacent circuitry when used for fine resolution electronic application printed circuits. The growth rate is encouraged slightly by elevated temperature and humidity, but is greatly promoted by high stresses (causing growth in a matter of hours). Such high stresses occur in thin tin or solder coatings (less than about 100 microinches) and will be higher in electrodeposited coatings because of the stresses which are impressed by the flow of current, not present in the electroless and immersion coating methods.

As shown by the foregoing, an electroplated alloy layer including tin may be subject to formation of tin whiskers due to stress imposed by the electroplating process itself, while an immersion plated alloy layer would not.

As shown by the foregoing, there is a structural difference between an electroplated metal layer and an immersion plated metal layer.

Second, Applicants submit herewith a single page Internet publication from <http://www.leadfree.org> relating to the problem of tin whiskers. The original publication date of this publication is not known; however the copy submitted was obtained on June 18, 2003. This publication states that the critical precursors that increase the propensity towards whiskering include stress in the tin coating, which can arise in electrolytically plated deposits. As is known in the art, such stresses do not occur with immersion plating. The publication further states that the tin whiskering problem may be mitigated by adding another element such as bismuth to the plating bath, but then points out that doing so brings concerns relating to workability and difficulty in controlling the solder bath.

Applicants submit that the leadfree.org publication shows that the tin whiskering problem is a long-felt, on-going problem and that others have failed to solve the problem. Further, Applicants submit that the teachings of the leadfree.org publication with respect to bismuth constitutes a teaching away from the use of alloys as a solution to the tin whiskering problem.

Third, Applicants submit herewith an Internet publication from CALCE Electronic Products & Systems Center at the University of Maryland (CALCE is believed to be an acronym for "Computer Aided Life Cycle Engineering"), all relating to the on-going problem of tin whiskers (referred to herein as "the CALCE publication"). The copyright date on the CALCE publication is 2002, and various of the papers show initial or revision dates in June and July, 2002. The CALCE publication is submitted to show that the problem of tin whiskers continues, and that Applicants' presently disclosed and claimed invention would not have been obvious over the prior art, since if it were obvious it would have been done long ago in response to the long-recognized tin whisker problem.

Included in the CALCE publications is a single page "Tin Whisker Alert", which states that the tin whisker failure mode is re-emerging as a significant problem, particularly with respect to satellites, missiles and other equipment, and stating that existing approaches are not sufficient to control tin whiskering.

Also included in the CALCE publications is a "Position Paper on Risks to High-Reliability Electronics and Associated Hardware from Pure Tin Coatings." This paper reiterates the statements in the "Tin Whisker Alert", provides an overview of the historical experience with tin whiskers, and notes that while addition of lead to tin may mitigate the whisker problem, this solution is undesirable due to the push to eliminate lead.

Included in the Position Paper is an Appendix A. In a paragraph bridging from page 1 to 2, Appendix A notes that "the difficulty with addressing the tin whiskering issue stems from the enormous disparities in the literature among its reported drivers as well as from the difficulty in identifying the failure-producing whiskers during failure analysis and post-mortems." This indicates that even when a source, such as the Tanimoto et al. patent, initially finds no tin whiskers, the problem in actuality may have not been solved and tin whiskers may yet appear.

On page 3 of Appendix A, it is noted that "addition of trace elements to tin plating used for soldering electronic components may result in lower failure fatigue durability of the solder interconnect", which may be considered to be a teaching away from the use of alloys as a solution to the tin whiskering problem. Such teaching away would lead away from, not to, use of the teachings of Tanimoto et al. with respect to the use of alloys as a solution to the tin whiskering problem.

On pages 4-5 of Appendix A, a number of mitigating actions currently under investigation are listed. Significantly, the use of immersion plating is not mentioned, and the use of alloy layers is not mentioned.

Also included in the Position Paper is an Appendix B. In the first paragraph on page 1 of Appendix B is the statement that the actual number of failures caused by tin whisker is difficult to determine, because many may not have been reported. This is posited to be because of the sensitivity of such failures. Consistent with the other disclosures from CALCE, this indicates that the tin whisker problem is an on-going problem that has not yet been solved.

Finally, the CALCE publications include "Mitigation Strategies for Tin Whiskers". This paper provides a detailed discussion of various proposed mitigation strategies for solving or reducing the problem of tin whiskers. Significantly, there is no mention or suggestion of the use of an immersion plated alloy cap layer, and there is no mention of an alloy layer as a solution to the tin whisker problem.

In addition to the foregoing, Applicants respectfully submit that the both the leadfree.org publication and the CALCE publication show that the problem of tin whiskering is a long-standing problem in the art, and show a failure of others to solve the problem of tin whiskering, notwithstanding the apparent teaching of Tanimoto et al. of such solution. Evidence that an invention solves a long-standing problem in the art is probative of non-obviousness, as is the failure of others to find such a solution. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 [148 USPQ 459] (1966); *Panduit Corp. v. Dennison Mfg. Co.*, 1 USPQ2d 1593, 1595 (Fed. Cir.), *cert. denied*, 481 U.S. 1052 (1987). Here, Applicants provide a solution to the problem of tin whiskering which is distinct from the prior art, and which solution, while long-sought, has eluded many researchers in the art for many years, as shown by these documents.

In conclusion, Applicants respectfully submit that the evidence submitted herewith shows (1) that the layers deposited by an immersion plating process are not the same as layers deposited by an electroplating process; (2) that the tin whiskering problem is a long-standing problem, long-felt but yet unsolved in the art; and (3) that Applicants' claimed invention would not have been obvious over the prior art as represented by Nakayama et al. and Tanimoto et al.

Both the teachings of U.S. Patent No. 4,234,631 and the leadfree.org publication show that there is a non-obvious physical difference between an electroplated metal layer and an immersion plated metal layer. The electroplated layer may include stresses that can give rise to tin whiskering. The immersion plated layer is free of such stresses.

Both the leadfree.org publication and the CALCE publication show that the tin whiskering problem is a long-felt and until now un-met need, that the assertedly obvious

combination of elements selected from Nakayama et al. and Tanimoto et al. in fact would not have been obvious and, most importantly, that Applicants' presently disclosed and claimed invention would not have been obvious over the prior art generally and would not have been obvious over the combination of Nakayama et al. and Tanimoto et al., as asserted by the Examiner.

## **2. Nakayama Teaches Away From the Asserted Combination.**

Nakayama clearly teaches away from the use of an alloy cap layer. In Applicants' first Reply, Applicants point out a clear teaching away, at col. 2, lines 48-55 of Nakayama et al. The Examiner failed to address this point in the final Office Action, and failed to rebut Applicants' arguments and evidence in this regard. Nakayama et al. includes additional disclosure which teaches away from the asserted combination thereof with Tanimoto et al., and which teaches away from Applicants' claimed invention.

From col. 3, line 65 to col. 4, line 6, Nakayama further elaborates on the problem of tin whiskering, and states that tin alloys would not work. Nakayama states:

The term "tin alloy" as used herein means any of tin alloys usually used for plating film carriers, with the latent possibility of generating whiskers, and which can be employed for electroless alloy plating, as typified by solder and excluding indium-containing alloys. Tin alloy plating without any potential of whisker generation would leave no room for application of the present invention. Actually, however, it is next to impossible to obtain such general-purpose, whisker-free tin alloy platings. (Emphasis added.)

Applicants understand this disclosure of Nakayama et al. to state that electroless tin alloy plating is not compatible with the invention disclosed therein, and to state that, in any event, tin alloy plating would not work to avoid tin whiskers. Applicants note that the latter statement broadly refers to tin alloy plating, without specifying electroless tin alloy plating.

It is difficult to imagine a more clear and unequivocal teaching away from the use of tin alloy coatings than this.

In view of this clear and unequivocal teaching away, no person of ordinary skill in the art would be motivated to attempt the combination of Nakayama et al. and Tanimoto et al., even if Tanimoto et al. teach that electroplated tin alloys do not form tin whiskers. As noted above with respect to the leadfree.org and CALCE publications, given that there is an on-going problem with tin whiskers, a person of ordinary skill in the art would not be lead to combine Nakayama et al. with Tanimoto et al. in the manner asserted by the Examiner.

The Examiner justified the combination based on the alleged motivation arising from the Tanimoto et al. teaching of tin whisker-free electroplated tin alloy layers. At best, this teaching of Tanimoto et al. would be an invitation to experiment, and does not provide or show evidence of a motivation to combine. Invitation to experiment, i.e., "obvious to try", is not the standard by which obviousness is determined. "Obvious to try" has long been held not to constitute obviousness. *In re O'Farrell*, 7 USPQ2d 1673, 1680-81 (Fed. Cir. 1988). A general incentive does not make obvious a particular result, nor does the existence of techniques by which those efforts can be carried out.

Based on this clear teaching away, there can be no motivation for making the asserted combination, the Examiner's rationalizations therefor notwithstanding. Since there is no motivation for making the asserted combination, there can be no *prima facie* case of obviousness of the presently claimed invention over the asserted combination of Nakayama et al. in view of Tanimoto et al. Accordingly, for this additional reason, Applicants respectfully request the withdrawal of the rejections over these references.

### **CONCLUSION**

For the foregoing reasons, Applicants respectfully submit that the presently claimed invention would not have been obvious over Nakayama et al. in view of Tanimoto et al.. Applicants respectfully submit that the presently claimed invention patentably distinguishes

over the prior art. Applicants respectfully submit that the herein-submitted drawing figure contains no new matter, and provides the drawing requested by the Examiner.

Accordingly, Applicants respectfully submit that the present application is in condition for allowance, and request notice to such effect.

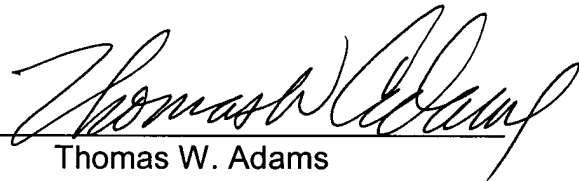
If the Examiner considers that a telephone interview would expedite prosecution, Applicants request that the Examiner telephone the undersigned to expedite allowance of the application. No additional fees are believed required as a result of the present paper; however, in the event such fees are required, the Commissioner is authorized to charge those fees to Deposit Account #18-0988, Docket No. MCGEP0178USA.

Respectfully submitted,

RENNER, OTTO, BOISSELLE & SKLAR, LLP

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By



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## Tin Whiskers

A large area of concern with the use of tin-plated or pure tin component finishes is the occurrence of tin whiskers. This condition, also known as tin pest and tin disease, arises when tin reaches a certain temperature (usually below 10° C) and begins to grow tiny dendrites known as whiskers. These whiskers tend to flake off, leading to concerns with reliability of the solder joint.

The critical precursors that increase the propensity towards whiskering include:

- Stress in the coating.
- Purity.
- Thickness range.
- To a degree, the crystal structure.

Highly stressed deposits of 2 - 10 microns of pure tin are probably the most susceptible and, hence electrolytically plated deposits can be a particular problem. This stress effect can also be demonstrated by scratching tin deposits and watching these areas preferentially whisker. Immersion deposits, which are thinner (say 0.5 - 1.5 microns), and which have a more polygonized structure are much less prone.

Ways of avoiding whiskers include the addition of another element to the plating bath, such as bismuth. Adding bismuth brings concerns with its sometimes poor workability with lead bearing alloys and the difficulty in controlling the solder bath.

Several tests have been conducted to stimulate tin whisker growth to determine whether whiskers pose a reliability problem or not. One such test currently underway through the auspices of the EIA Soldering Technology Committee and the IPC Alternate Finishes Task Group subjects samples to a 51° C ambient air bake. The groups are testing a variety of plated samples including flat strips, 180° bend coupons and actual gull wing formed leaded surface mount components.

[BACK](#)



Bokisa, et al.; Serial No. 10/002,714  
Filed: Nov. 1, 2001; GAU 2827  
Atty. Docket No. MCGEP0178USA

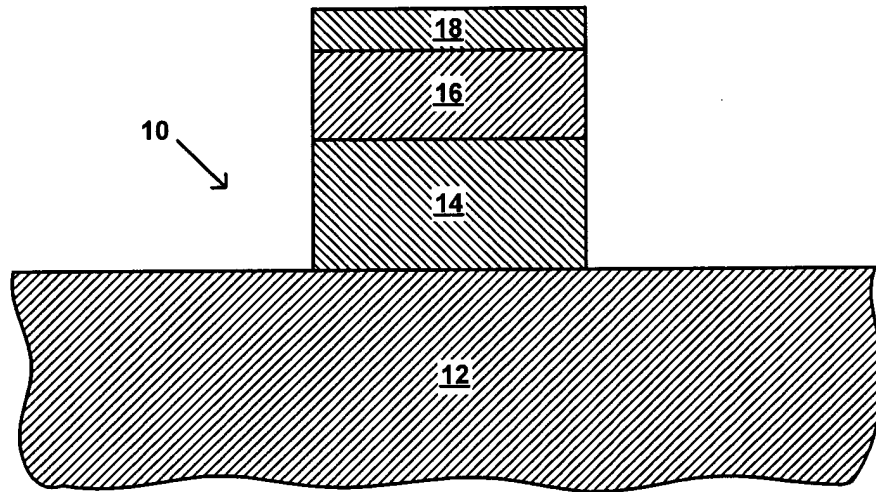


Fig. 1

*This drawing has been amended  
only by inclusion of cross-hatching.*